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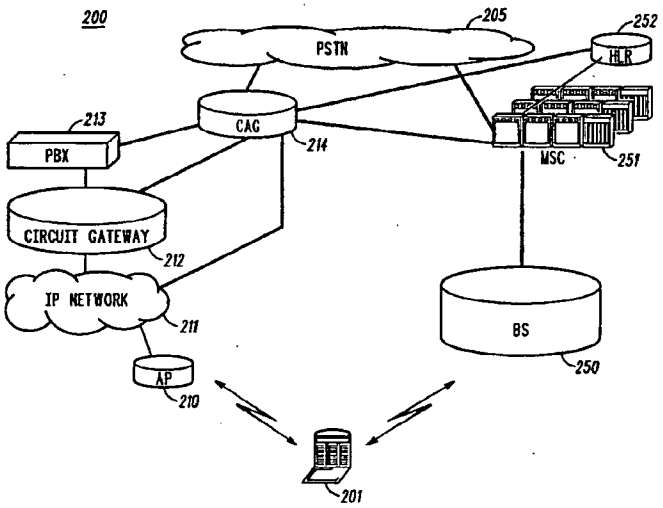

(57) Abstract: To address the need for an apparatus and method for handoff from a cellular wireless network to a non-cellular wireless network (WLAN, e.g.), the present application describes an access gateway (214) and a dual mode mobile station (201) that enable such handoffs. Dual mode MSs can determine when a handoff to a non-cellular network is preferred and request a handin (302) from the non-cellular network. The access gateway provides information to the MS (304) so that it can initiate a handoff through the serving cellular network. Triggering handoffs in this manner, allows cellular networks to handle handoffs to non-cellular networks in much the same way they handle inter-MSC handoffs today, i.e., source initiated.

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METHOD AND APPARATUS FOR A SOURCE-INITIATED HANDOFF FROM A SOURCE CELLULAR WIRELESS NETWORK TO A TARGET NON-CELLULAR WIRELESS NETWORK

Cross-Reference To Related Application

This application is related to a co-pending application entitled "METHOD AND APPARATUS FOR A TARGET-INITIATED HANDOFF FROM A SOURCE CELLULAR WIRELESS NETWORK TO A TARGET NON-CELLULAR WIRELESS NETWORK", filed on even date herewith, and assigned to the assignee of the instant application.

Field of the Invention

The present invention relates generally to wireless communication systems and, in particular, to handoff from a source cellular wireless network to a target non-cellular wireless network.

Background of the Invention

With the growing popularity of non-cellular wireless networks, such as wireless local area networks (WLANs), a demand for integration with overlaid or adjacent cellular networks has arisen in the marketplace. A solution for the integration of WLAN and cellular networks must include the ability to perform seamless handovers at least for voice services. Current cellular systems (e.g., GSM and CDMA) allow for such mobility between cell sites, but technology does not currently exist to allow calls to be maintained across a cellular-to-WLAN border. Without this capability, a voice call would be dropped at the border of

the two systems, or in an overlay situation, the call may continue but not under the control of the optimal or preferred system for that location. Therefore, a need exists for an apparatus and method for handoff from a cellular wireless network to a non-cellular wireless network.

An overview of some handoff prior art will support the novelty of the invention described below. Handoffs across different wireless technologies have been accomplished before, for example, between CDMA and analog cellular. CDMA to analog handoff based on DAHO (Database Assisted Handoff) is a specific example. DAHO initiates a handoff from CDMA to analog based on the existence of pilot signals and location information stored in the source cellular system. However, this is not a viable solution for a CDMA-WLAN system because the number of WLAN APs are much larger than analog base stations, thus requiring very large databases to be stored in each CDMA base site. Consequently, this approach would be cumbersome and complex.

Similar to CDMA-analog handoffs, UMTS-GSM handoffs are known. These handoffs are enabled by incorporating changes in the GSM and UMTS base sites to recognize each other's cell sites. This is done by modifying the existing list of neighboring cells to include cells of the other technology. Specific changes to handover signaling between the MS and the BS is also required to enable the handover. The invention described below does not involve any changes to the neighbor lists or introduce any new handover signaling between the MS and the cellular BS.

Inter-MSC (mobile switching center) handoffs are defined in CDMA IS-95 B and GSM systems to provide handoffs between two base sites that are controlled by distinct MSCs. The Inter-MSC handoff procedures as defined in all cellular networks are initiated by the source MSC (the MSC currently serving the serving base site). The current IS-41 and MAP procedures (the interfaces governing the handoff procedure in CDMA and GSM respectively) only provide for source initiated handoffs. This can be seen, for example, in FIG. 1. FIG. 1

illustrates the inter-MSC handoff procedure for IS-95 systems based on the IS-41 specifications. (MAP procedures for GSM are similar.)

The known handoff procedure begins with the mobile station (MS) generating a CDMA Pilot Strength Measurement Message (PSMM) 1. The PSMM message contains the PN offsets and signal strengths (Ec/Io) of pilots in the MS's candidate and active set. The base site (BS) determines that the PN offset sent in the PSMM does not correspond to a cell under its control. The BS generates a Handoff Required message 2 containing the Cell Identifier List (with Cell ID, and optionally more information like MSC ID, LAC, etc). The source MSC then identifies the target BS and the associated MSC. It sets up a terrestrial circuit to the target MSC, and sends an IS41_FACDIR2 message 3. The message contains the inter-MSC circuit ID, target cell ID, and other handoff-related parameters like channel condition, etc. The target MSC then initiates a Handoff Request 4 to the appropriate target BS. The message contains parameters that are mostly obtained (directly transferred) from the FACDIR2 message.

A Handoff Request Ack 5 is sent by the target BS to the MSC after radio resources and terrestrial circuits are allocated, and an IS_41_facdir2 6 is sent to the source MSC containing the parameters obtained from the Handoff Request Ack message. The Handoff Command 7 is then sent to the source BS to begin the handoff procedure, and the information in this message is used to generate an IS95_Extended Handoff Direction Message 8, containing the new frequency channel and frame offset. The IS95_Handoff Direction Message instructs the MS to switchover to the target cell/BS and start sending preamble frames on the reverse channel. The MS acks this message by sending an IS95_Extended Handoff Direction Ack Message 9 to the source BS. The source BS then sends a Handoff Commenced message 10 to the source MSC indicating that the handoff is progress.

When ready, the MS sends an IS_95 Handoff Completion message 11 to the target BS. The target BS then sends a Handoff

Complete message 12 to the target MSC, and the target MSC informs the source MSC of the successful handover with an MSONCH message 13. Finally, a Clear Command message 14 and a Clear Complete message 15 are exchanged in order to release resources between the source BS and the source MSC.

Two aspects of this prior art handoff messaging are particularly pertinent. First, it is the MS that identifies the handoff target to the source BS and MSC by providing the PN offset of the target. Second, it is the source MSC that initiates the handoff messaging (see FIG. 1, message 3) by translating the PN offset to a target BS/MSC. However, if the target system were a WLAN system, the handoff target would be a WLAN access point (AP), and presently there is no messaging to enable either the MS or the source MSC to identify this target WLAN AP.

Brief Description of the Drawings

FIG. 1 is a message flow diagram of prior art messaging exchanged by system components to affect a handoff.

FIG. 2a is a block diagram depiction of a communication system in accordance with an embodiment of the present invention.

FIG. 2b is a block diagram depiction of communication system components in accordance with an embodiment of the present invention.

FIG. 3 is a messaging flow diagram of messaging and information exchanged by system components to affect a handoff in accordance with an embodiment of the present invention.

Detailed Description of Embodiments

To address the need for an apparatus and method for handoff from a cellular wireless network to a non-cellular wireless network (WLAN, e.g.), the present application describes an access gateway and a dual mode mobile station that enable such handoffs. Dual mode MSs can determine when a handoff to a non-cellular network is preferred and request a handin from the non-cellular network. The access gateway provides information to the MS so that it can initiate a handoff through the serving cellular network. Triggering handoffs in this manner, allows cellular networks to handle handoffs to non-cellular networks in much the same way they handle inter-MSC handoffs today, i.e., source initiated.

The disclosed embodiments can be more fully understood with reference to FIGs. 2a, 2b, and 3. FIG. 2a is a block diagram depiction of communication system 200 in accordance with an embodiment of the present invention. Communication system 200 comprises a known wireless local area network (WLAN), a known cellular network, and components to interface them together, the combination suitably modified to implement the present invention. The WLAN is a known wireless infrastructure such as that conforming to the IEEE 802.11 standard. The cellular network is a well-known Code Division Multiple Access (CDMA) network, based on the Telecommunications Industry Association / Electronic Industries Association (TIA/EIA) standard IS-95. (The TIA/EIA can be contacted at 2001 Pennsylvania Ave. NW, Washington, D.C. 20006). In various alternative embodiments, communication system 200 may utilize other cellular communication protocols such as, but not limited to, GSM, UMTS, IS-2000, and "IDEN."

The cellular network of communication system 200 includes known radio access network (RAN) entities, such as base site (BS) 250 (comprising a base site controller and one or more base transceiver stations), mobile switching center (MSC) 251 (which interfaces with

PSTN 205), and home location register (HLR) 252. Communication system 200 further includes WLAN access point (AP) 210, internet protocol (IP) network 211, circuit gateway 212, private branch exchange (PBX) 213, and cellular access gateway (CAG) 214. Both the WLAN and cellular network of system 200 support voice services. The WLAN supports voice over a pico-cellular environment, while the cellular network supports voice over the macro-cellular environment. As integrated into system 200, these networks further support voice-session mobility from the cellular network to the WLAN.

Communication system 200 also includes mobile stations (MSs), such as MS 201. MS 201 is a dual-mode phone capable of communicating with both the cellular network (e.g., BS 250) and the WLAN (e.g., AP 210). FIG. 2b depicts MS 201 is greater detail. MS 201 comprises well-known entities such as processor 204, dual-mode transmitter 202, and dual-mode receiver 203. Transmitters, receivers, and processors as used in MSs are all well known in the art. This common set of MS components is adapted using known telecommunications design and development techniques to implement the wireless unit aspect of the present invention. Processors typically comprise components such as microprocessors, digital signal processors, memory, and/or logic circuitry designed to implement algorithms that have been expressed as computer instructions and/or in circuitry. Given an algorithm or a logic flow, those skilled in the art are aware of the many design and development techniques available to implement a processor that performs the given logic.

FIG. 2b also depicts CAG 214 in greater detail. CAG 214 comprises a known network interface 215 and cellular interworking device 216. Network interface 215 provides an access gateway interface to IP network 211, while cellular interworking device 216 performs cellular mobility interworking (e.g., interworking for registration, authentication, and handoff) by interfacing with MSC 251, HLR 252, PBX 213, and circuit gateway 212. Cellular interworking device 216 also

performs PSTN interworking by interfacing with PSTN 205 using landline signaling protocols such as ISDN User Part (ISUP) and/or Multi Frequency R1 (MFR1). Generally, cellular and PSTN interworking components are known in the art. These components in addition to network interface components are combined and adapted using known telecommunications design and development techniques to implement the access gateway aspect of the present invention. Given a protocol or a message flow, those skilled in the art are aware of the many design and development techniques available to implement a networking platform that performs the specified function.

Furthermore, those skilled in the art will recognize that FIGs. 2a and 2b do not depict all of the network equipment and devices necessary for system 200 to operate fully but only those system blocks and logical entities particularly relevant to the description of embodiments of the present invention. Those skilled in the art are aware of the many ways the necessary devices and entities can be implemented and/or purchased from wireless networking companies and wireless communications companies such as "MOTOROLA."

High-level operation of a first embodiment of the present invention occurs substantially as follows. In the first embodiment, MS 201's dual mode functionality allows it to support voice services over the cellular network and the WLAN. Thus, MS 201 supports a standard cellular voice call model such as one specified by the GSM, CDMA, or "IDEN" technologies, for example. For the WLAN domain, MS 201 supports a voice over IP (VoIP) protocol, such as H.323, Session Initiation Protocol (SIP), or the Skinny Protocol of "CISCO." The VoIP protocols are used between MS 201 and circuit gateway 212. Circuit gateway 212, when connected to PBX 213, provides the interworking necessary for the desired PBX feature transparency to MS 201. Also, for signaling with WLAN AP 210, MS 201 supports IEEE 802.11 signaling in the first embodiment, but signaling types such as Bluetooth or HiperLAN 2 may additionally or alternatively be supported in other embodiments.

Lastly, the dual mode capability of MS 201 allows it to measure the signal strength of the WLAN AP(s), such as AP 210, as well as the cellular BTS(s), such as those of BS 250.

Generally, in the first embodiment, CAG 214 interworks the voice call model and mobility management within the WLAN domain with the voice call model and mobility schemes of the standard macro-cellular domain. It provides the required interworking between the WLAN and cellular domain in the areas of cellular registration, authentication, and cross-technology handovers. In addition, it also interworks the cellular network with the existing voice infrastructure (i.e., PBX 213 and circuit gateway 212) in the WLAN domain.

In the first embodiment, cellular interworking device 216 provides the appearance to a GSM / "IDEN" (MAP) or a CDMA (IS-41) cellular network that the WLAN domain is another standard cellular network. Cellular interworking device 216 enforces message discrimination by sending/receiving MAP/IS-41 messaging to/from an MSC/HLR. Cellular interworking device 216 effectively emulates either an MSC or a VLR role to the far-end macro-cellular domain.

In the first embodiment, cellular interworking device 216 also keeps subscriber profile, supports authentication, supports registration, etc. At a minimum, cellular interworking device 216 emulates a portion of the cellular VLR. It provides higher-layer mobility support to allow CAG 214 to act like a standard MSC to the macro-cellular MSC/HLR domain.

In addition, in the first embodiment, cellular interworking device 216 provides service logic similar to call processing, but not a complete set. The distinction typically is between service/feature "control" and service/feature "execution." There are only a few scenarios (e.g. handoff from cellular to WLAN) where cellular interworking device 216 provides full call processing, allowing the connection to be made (i.e., control) and setting up the bearer connection through CAG 214 (i.e., basic execution). Since CAG 214 is only involved in inter-domain session

establishment and handoffs, these scenarios require functionality to maintain the basic state of the subscriber's session. In most other scenarios, like a PSTN to WLAN session establishment, PBX 213 provides all call processing.

In the first embodiment, the general role of PBX 213 is to terminate circuit voice calls and provide call processing with access to voice features as if MS 201 were a typical wired telephone in the enterprise domain. In addition, the general purpose of circuit gateway 212 is to interwork the voice call models in the WLAN-IP domain and the typical circuit (i.e., PBX) domain. This requires both bearer and control interworking. The voice bearer and signaling from dual mode MS 201 and WLAN APs connect over IP and may use IP telephony call model conventions. Since the IP telephony conventions do not work with the typical wired PBX, circuit gateway 212 provides this important interworking to PBX 213.

Messaging-focused operation of the first embodiment of the present invention occurs substantially as follows. FIG. 3 is a messaging flow diagram 300 of messaging and information exchanged by system components to affect a handoff from a cellular wireless network to a non-cellular wireless network (e.g., a WLAN) in accordance with the first embodiment of the present invention. Already involved in a call, MS 201 receives call information (301) via serving BS 250 and associated (i.e., serving) MSC 251. This call information refers to real-time call content such as voice or video-telephony.

As MS 201 moves within the coverage area of WLAN AP 210, MS 201 performs signal strength measurements and establishes contact with AP 210. Establishing contact typically involves obtaining an IP address for itself (MS 201) and for an access gateway (CAG 214, in the first embodiment). At some point, MS 201 determines that a handoff from serving BS 250 to AP 210 is preferred. MS 201 may determine this based on criteria such as the relative signal strength of BS 250 and AP 210, the relative cost of wireless service, and/or user indications of

preference. For example, the user may set an MS option to switch to WLAN service whenever signal conditions allow or whenever the WLAN service is determine to be cheaper.

Having determined that a handoff is preferred, processor 204 sends a handin request (302) to CAG 214. The request is sent to CAG 214 via transmitter 202, WLAN AP 210, and IP network 211. Thus, the handin request is sent using an IP packet addressed to CAG 214. The handin request contains an indication of from which cellular wireless network MS 201 is attempting to handoff, i.e., which MSC is serving MS 201. The indication takes the form of a serving cell identifier which CAG 214 can use to determine the corresponding serving MSC. In the first embodiment, this serving cell identifier is the PN offset of MS 201's serving cell within BS 250, while in an alternative GSM embodiment, the serving cell identifier may be the Base Transceiver Station Identity Code (BSIC) of MS 201's serving cell.

Cellular interworking device 216 of CAG 214 receives the IP-packetized handin request from MS 201 via network interface 215. In response to MS 201's handin request, cellular interworking device 216 sends a handin request acknowledgment (304) to MS 201. This handin request acknowledgment is sent via network interface 215, IP network 211, and WLAN AP 210. Importantly, the acknowledgment contains a handoff-target identifier, such as a cell identifier. In the first embodiment, this handoff-target identifier is a value that is predefined to trigger an automatic handoff determination by the cellular wireless network from which the MS is attempting to handoff. In other words, it could be either a "spoof" value or a valid cell identifier that will be recognized (i.e., the cellular network has been preprogrammed to recognize) as a trigger for handoff to this non-cellular network. In an alternative embodiment, the handoff-target identifier may simply be a valid cell identifier for the non-cellular network that will not be specially recognized.

Processor 204 of MS 201 receives the handin request acknowledgment via WLAN AP 210 and receiver 203. After receiving

the acknowledgment, processor 204 sends a signal strength message (306) via transmitter 202 to serving BS 250. This signal strength message comprises values intended to trigger a handoff determination. Specifically, in the first embodiment, the signal strength message is a CDMA PSMM containing the handoff-target identifier from the handin request acknowledgment. Thus, the PSMM is sent in order to trigger a handoff to the WLAN, as identified by the handoff-target identifier. Alternatively, the PSMM could contain a regular cell identifier for the WLAN but with an artificial signal strength value associated with the cell identifier, which is intended to trigger a handoff to the WLAN identified by the cell identifier. In an alternative GSM embodiment, the signal strength message could instead be either a MEAS_RES (Measurement Result) message or a MEAS_REP (Measurement Report) message.

Thus, it is the handoff source (i.e., the serving cellular network) that initiates the handoff of MS 201 from the cellular network to the WLAN. However, for this to occur, handoff-target information is sent to the MS by the target network (i.e., the WLAN). This information is then used by the MS to trigger the handoff procedures. Note, that the cellular network needs to be able to recognize the handoff-target identifier that it receives in the PSMM, so some sort of agreement that addresses this between the network operators of the WLAN and cellular network is envisioned.

BS 250 receives the PSMM and determines that a handoff for MS 201 should be initiated. BS 250 sends a handoff required message (308) to MSC 251, and serving MSC251 then sets up the necessary circuits and sends a FACDIR2 message. CAG 214 receives the MAP FACDIR2 message (310) from serving MSC 251 and sends a MAP facdir2 message (312) back in response.

Serving MSC 251 then sends an initiate handoff message (314) to serving BS 250. In the first embodiment, this initiate handoff message would be a Clear Command signaling serving BS 250 to clear its wireless resources supporting MS 201. Release channel messaging

particular to the cellular network (e.g., IS-95 or GSM messaging) is then exchanged (316) between MS 201 and BS 250. For example, processor 204 of MS 201 receives a handoff release indication from BS 250 via receiver 203. In the first embodiment, this indication would be a CDMA Handoff Direction Message, while in an alternative GSM embodiment this indication may be a HND_CMD (handoff command) message.

After completing channel release messaging, processor 204 of MS 201 sends a handoff complete indication (318) to CAG 214 via transmitter 202, WLAN AP 210, and IP network 211. Thus, the handoff complete indication is sent using an IP packet addressed to CAG 214. Cellular interworking device 216 of CAG 214 receives the IP-packetized handoff complete indication from MS 201 via network interface 215. In response to this indication, cellular interworking device 216 sends an indication to MSC 251 that the MS is on channel (320). Specifically, this indication is a MAP MSONCH message.

MSC 251 then switches the MS 201 call information to CAG 214. CAG 214 receives the call information (via DS0 signaling, e.g.) and routes (321) it to MS 201 via IP network 211 and WLAN AP 210. Thus, MS 201 completes a handoff from the cellular network to the WLAN, continuing to receive its call information via MSC 251, CAG 214, and WLAN AP 210.

In the foregoing specification, the present invention has been described with reference to specific embodiments. However, one of ordinary skill in the art will appreciate that various modifications and changes may be made without departing from the spirit and scope of the present invention as set forth in the appended claims. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of the present invention. In addition, those of ordinary skill in the art will appreciate that the elements in the drawings are illustrated for simplicity and clarity, and have not necessarily been drawn to scale. For example, the dimensions of some of the elements

in the drawings may be exaggerated relative to other elements to help improve an understanding of the various embodiments of the present invention.

Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments of the present invention. However, the benefits, advantages, solutions to problems, and any element(s) that may cause or result in such benefits, advantages, or solutions, or cause such benefits, advantages, or solutions to become more pronounced are not to be construed as a critical, required, or essential feature or element of any or all the claims. As used herein and in the appended claims, the term "comprises," "comprising," or any other variation thereof is intended to refer to a non-exclusive inclusion, such that a process, method, article of manufacture, or apparatus that comprises a list of elements does not include only those elements in the list, but may include other elements not expressly listed or inherent to such process, method, article of manufacture, or apparatus.

The terms a or an, as used herein, are defined as one or more than one. The term plurality, as used herein, is defined as two or more than two. The term another, as used herein, is defined as at least a second or more. The terms including and/or having, as used herein, are defined as comprising (i.e., open language). The term coupled, as used herein, is defined as connected, although not necessarily directly, and not necessarily mechanically. The term program, as used herein, is defined as a sequence of instructions designed for execution on a computer system. A program, or computer program, may include a subroutine, a function, a procedure, an object method, an object implementation, an executable application, an applet, a servlet, a source code, an object code, a shared library/dynamic load library and/or other sequence of instructions designed for execution on a computer system.

What is claimed is:

Claims

1. An access gateway able to facilitate handoff from a cellular wireless network to a non-cellular wireless network, the access gateway comprising:

a network interface; and

a cellular interworking device, communicatively coupled to the network interface,

adapted to receive a handin request from a mobile station (MS) via a non-cellular access point and the network interface,

adapted to send a handin request acknowledgment to the MS via the non-cellular access point and the network interface in response to the handin request,

adapted to receive a handoff indication from a mobile switching center (MSC) associated with the MS,

adapted to receive a handoff complete indication from the MS via the non-cellular access point and the network interface, and

adapted to send an indication to the MSC that the MS is on channel, in response to the handoff complete indication.

2. The access gateway of claim 1, wherein the cellular interworking device is adapted to perform cellular mobility interworking by interfacing with MSCs and home location registers (HLRs).

3. A method for facilitating handoff of a mobile station (MS) from a cellular wireless network to a non-cellular wireless network comprising:

receiving, by an access gateway, a handin request from the MS via a non-cellular access point;

sending, by the access gateway in response to the handin request, a handin request acknowledgment to the MS via the non-cellular access point;

receiving, by the access gateway, a handoff indication from a mobile switching center (MSC) associated with the MS;

receiving, by the access gateway, a handoff complete indication from the MS via the non-cellular access point; and

sending, by the access gateway in response to the handoff complete indication, an indication that the MS is on channel to the MSC associated with the MS.

4. The method of claim 3, further comprising:

receiving, by the access gateway, call information for the MS from the MSC; and

routing, by the access gateway, the call information to the MS via the non-cellular access point.

5. The method of claim 3, further comprising sending, by the access gateway, a MAP facdir2 message to the MSC in response to the MAP FACDIR2 message.

6. A mobile station (MS) able to handoff from a cellular wireless network to a non-cellular wireless network, the MS comprising:

a transmitter;

a receiver; and

a processor, communicatively coupled to the transmitter and receiver,

adapted to send, via the transmitter, a handin request to an access gateway via a non-cellular access point,

adapted to receive, via the receiver, a handin request acknowledgment from the access gateway via the non-cellular access point,

adapted to send, via the transmitter after receiving the handin request acknowledgment, a signal strength message to a serving

cellular base site, wherein the signal strength message comprises values intended to trigger a handoff determination,

adapted to receive, via the receiver, a handoff release indication from a serving cellular base site, and

adapted to send, via the transmitter and after receiving the handoff release indication, a handoff complete indication to the access gateway via the non-cellular access point.

7. A method for handing off from a cellular wireless network to a non-cellular wireless network comprising:

sending, by a mobile station (MS), a handin request to an access gateway via a non-cellular access point;

receiving, by the MS, a handin request acknowledgment from the access gateway via the non-cellular access point;

sending, by the MS after receiving the handin request acknowledgment, a signal strength message to a serving cellular base site, wherein the signal strength message comprises values intended to trigger a handoff determination;

receiving, by the MS, a handoff release indication from the serving cellular base site; and

sending, by the MS after receiving the handoff release indication, a handoff complete indication to the access gateway via the non-cellular access point.

8. The method of claim 7, wherein the handin request comprises an indication of from which cellular wireless network the MS is attempting to handoff.

9. The method of claim 7, wherein the handin request acknowledgment comprises a handoff-target identifier.

10. The method of claim 7, further comprising:

receiving, by the MS, call information via the serving cellular base site and a mobile switching center (MSC) associated with the MS; and

receiving, by the MS, call information via the non-cellular access point, the access gateway, and the MSC.

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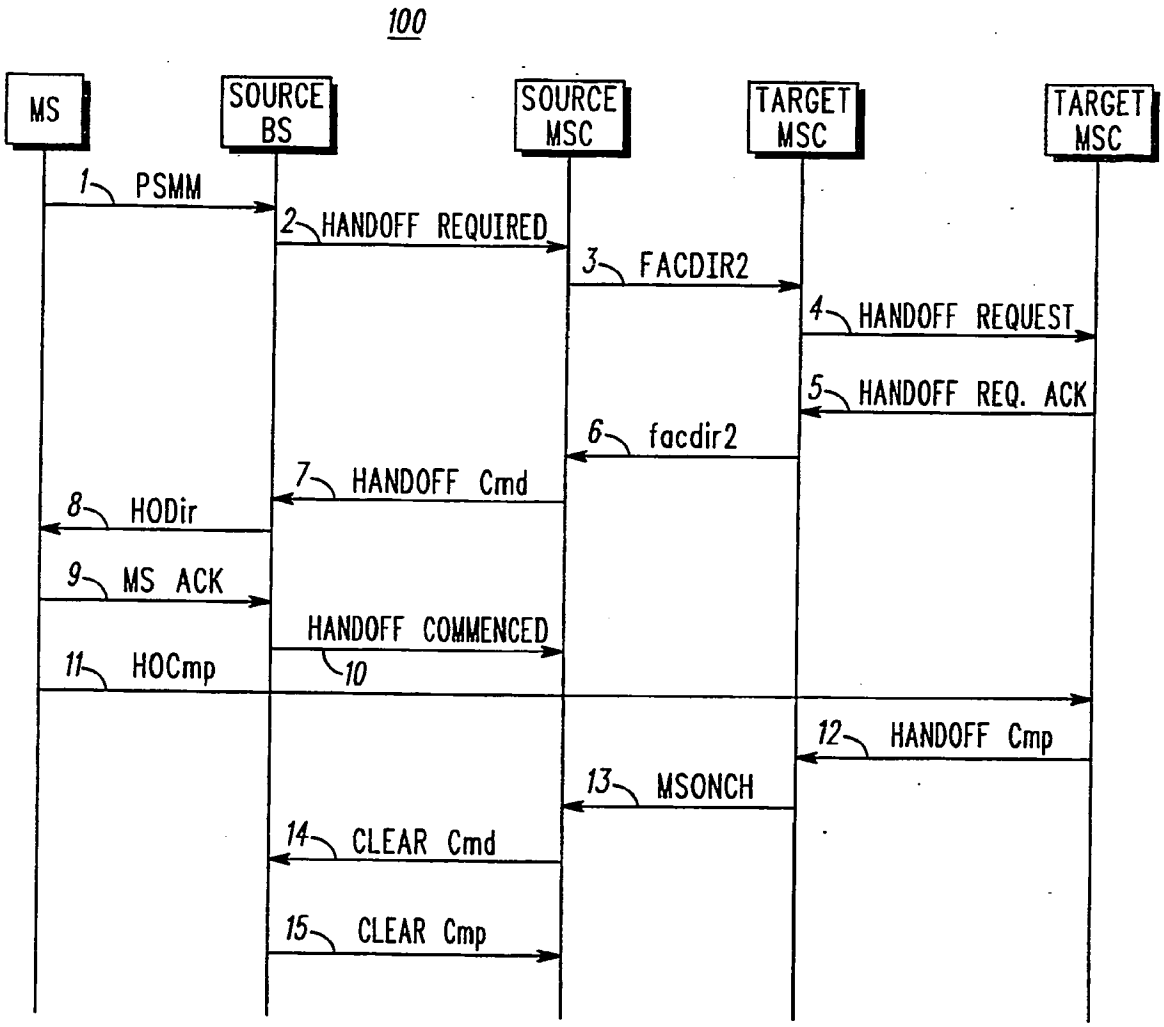

FIG. 1

—PRIOR ART—

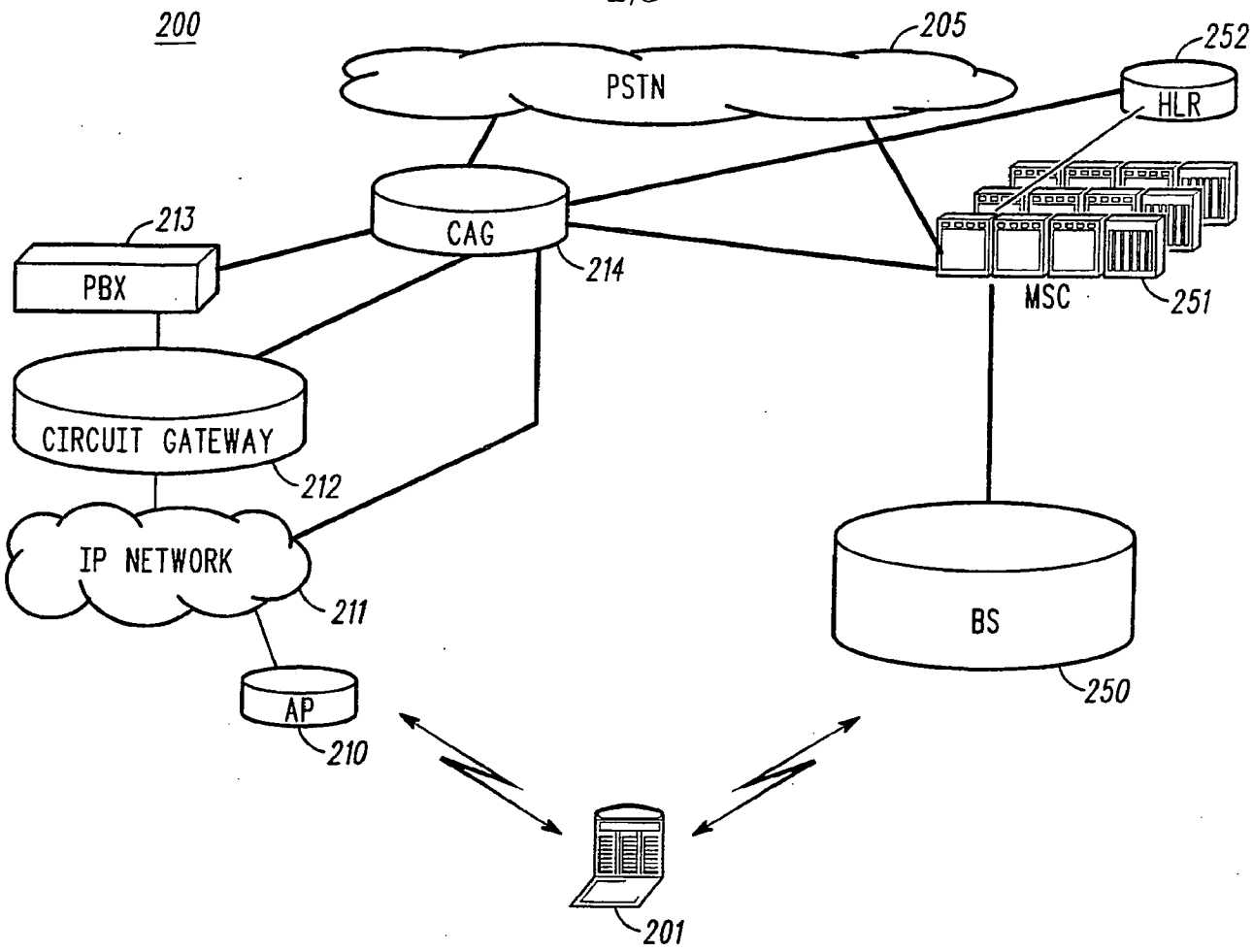

FIG. 2a

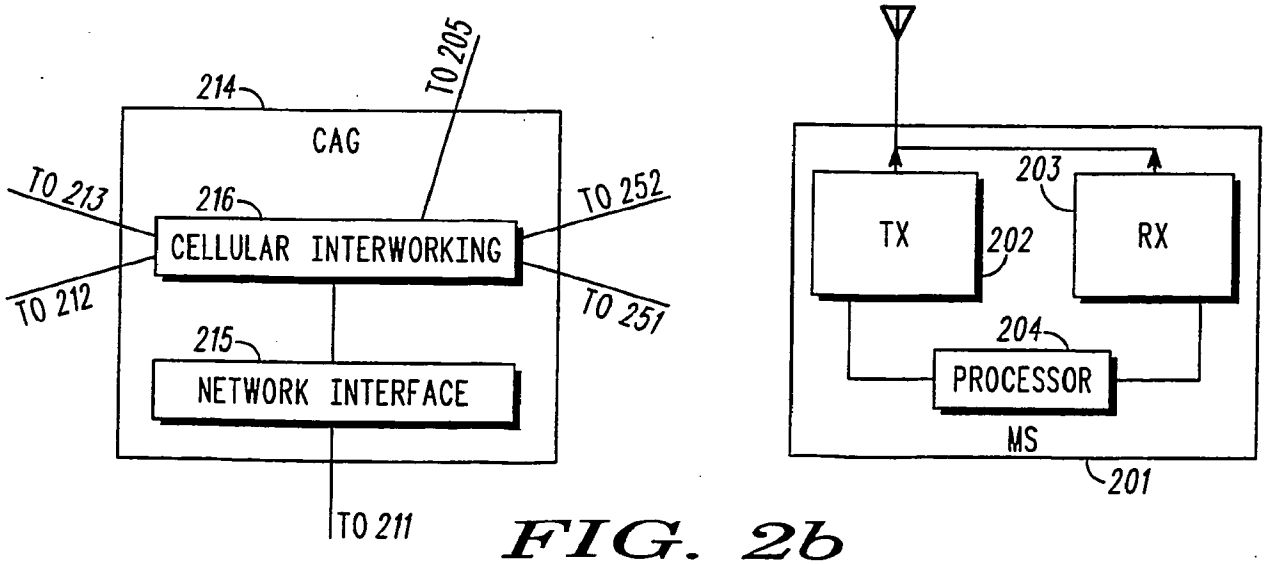

FIG. 2b

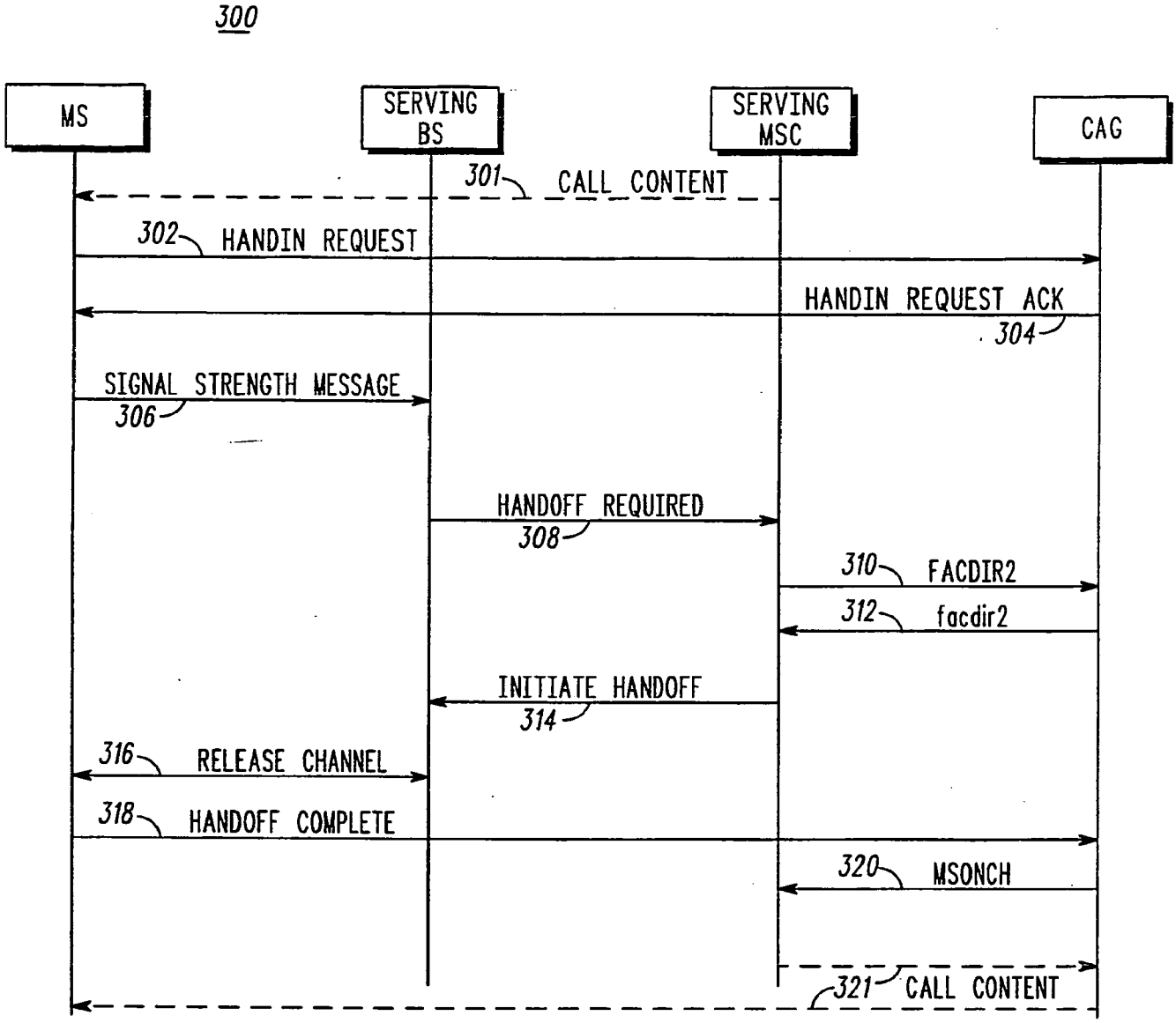

FIG. 3

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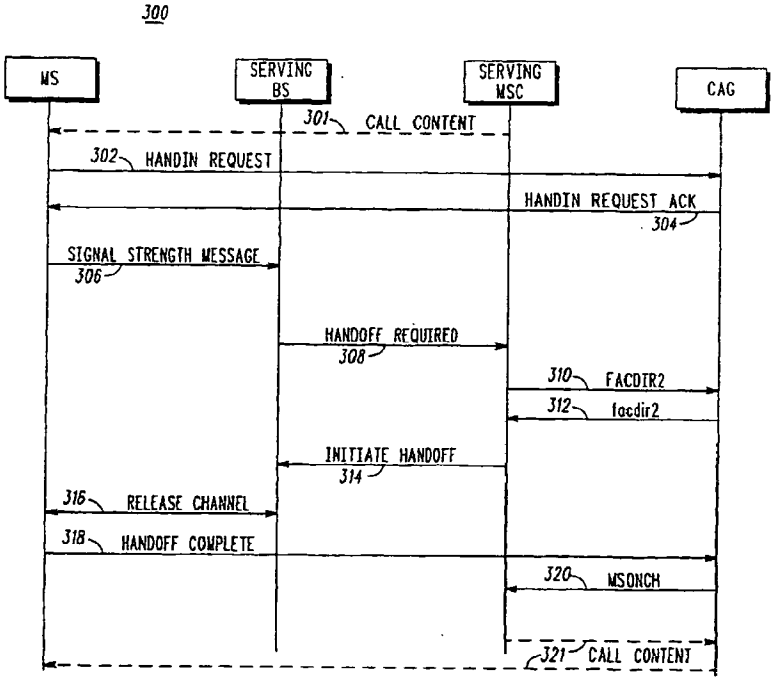
[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR A SOURCE-INITIATED HANDOFF FROM A SOURCE CELLULAR WIRELESS NETWORK TO A TARGET NON-CELLULAR WIRELESS NETWORK



(57) Abstract: To address the need for an apparatus and method for handoff from a cellular wireless network to a non-cellular wireless network (WLAN, e.g.), the present application describes an access gateway (214) and a dual mode mobile station (201) that enable such handoffs. Dual mode MSs can determine when a handoff to a non-cellular network is preferred and request a handin (302) from the non-cellular network. The access gateway provides information to the MS (304) so that it can initiate a handoff through the serving cellular network. Triggering handoffs in this manner, allows cellular networks to handle handoffs to non-cellular networks in much the same way they handle inter-MSC handoffs today, i.e., source initiated.

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Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2002/0085516 A1 (BRIDGELALL) 04 July 2002, Fig. 13, para [0075]-[0083].	1-10
A,P	US 2004/0002335 A1 (PAN et al) 01 January 2004, Fig. 1, para. [0024]-0027]	1-10
A,P	US 2003/0117978 A1 (HADDAD) 26 June 2003, para. [0020]-[0021]	1-10

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Date of the actual completion of the international search	Date of mailing of the international search report
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An Architecture for Integrating CDMA2000 and 802.11 WLAN Networks

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***Abstract*— Low cost, high speed wireless LAN networks can be integrated within the cellular coverage to provide hot spot coverage for high speed data services. This article presents a novel approach for integrating North American 3G cellular network and 802.11 wireless LAN networks. The inter-technology mobility is supported using the standard cdma2000 functions and signaling.**

Keywords: IEEE802.11, CDMA2000, mobility, hot spot, heterogenous networks

I. INTRODUCTION

The 3G cellular networks are designed to offer high speed access for mobile data users. However, the demand for bandwidth in the 3G cell is not uniform throughout the cell. Rather, it is clustered in hotspot areas such as airports, hotels, shopping malls, apartment buildings, Internet cafes etc. In addition, the availability of bandwidth in the 3G cell is not uniform throughout the cell. In general, higher bandwidths are only available close to the cell site while only lower bandwidths are available further from the cell site. Fading and obstructions further affect the availability of bandwidth at any point within the cell. IEEE 802.11 Wireless LAN (WLAN) is a short-radius radio technology that is gaining a tremendous momentum in the marketplace. The cellular operator can take advantage of this low cost, high speed technology to cover the hot spots and gaps in coverage within its cellular network. In such scenarios, the mobile wireless access network is expected to be heterogeneous in nature and may allow the mobile user to move between the 3G cellular to the WLAN coverage area and vice versa. However, neither the existing 3G cellular nor the WLAN standards provide an integrated network architecture to support seamless mobility of the user between the two technologies. An integrated network architecture to support 3G UMTS network and WLAN is presented in [1]. Some other related work on WLAN inter-operability can be found in [2, 3, 4]. In this article, we propose a novel architecture to allow seamless mobility between the North American 3G cellular standard (cdma2000) and 802.11 WLAN networks. This proposal reuses the standard cdma2000 functions and signalling messages to perform an inter-technology handover.

II. BACKGROUND

A. CDMA2000 Network

The 3rd generation North American wireless standard [5] is based on cdma2000 radio technology. It provides circuit-switched (CS) service for voice and the packet-switched (PS) service for data transport. The network between the mobile station and the base station controller (BSC) (including the base station BTS) forms the radio access part of the cdma2000 network (Figure 1). The packet network is represented by the R-P (radio-to-packet) interface between BSC and packet data serving node (PDSN). The generic encapsulation protocol (GRE) [18] is recommended for the R-P interface. A packet control function (PCF) at the BSC handles the packet signaling and data transfer between the radio and packet parts of the cdma2000 network. End-to-end packet data between the mobile station and the packet data serving node (PDSN) is transported through the Point-to-Point Protocol (PPP) [11].

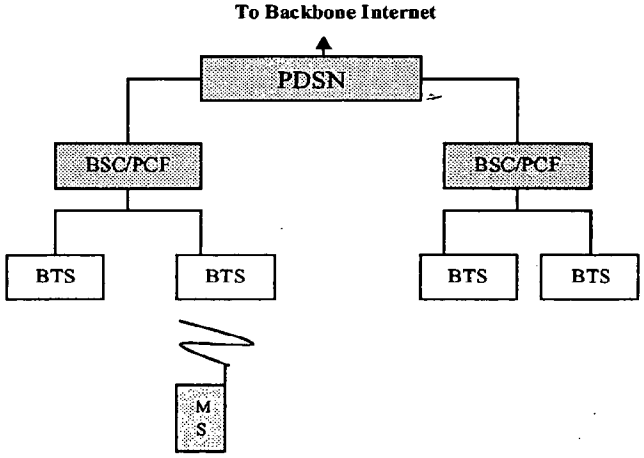

Figure 1. An Example of CDMA 2000 Network

B. 802.11 WLAN and IP over WLAN

The IEEE 802.11 WLAN [7, 8, 9] network is composed of a number of access points (APs) and the Mobile Stations (MS) accessing the WLAN network through one of the APs. A

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number of APs can be interconnected through an IP routed network to form the WLAN IP network. An access router (AR) connects one or more APs to the IP access network. An access network gateway (ANG) connects the WLAN IP access network to the backbone Internet world, as shown in Figure 2.

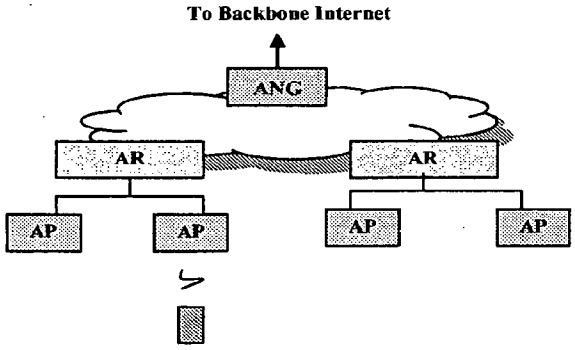

Figure 1. An Example of WLAN IP Network

A. *CDMA2000 and WLAN Integration: HotSpot Scenario*

A hotspot area is defined as a dense population of the users in a small area. An operator may have cellular coverage across these areas but it may want to provide lower cost, higher speed coverage to the users in the hot spot area. In this hot spot scenario, WLAN is used primarily for data connection only and it operates in conjunction with the cdma2000 cellular network. Users with dual-mode mobile devices can access the two networks. The devices have two network interfaces - one connects with the cellular network and the other with WLAN network. It is possible to use common billing and network authentication infrastructure as well as common connectivity to the Internet.

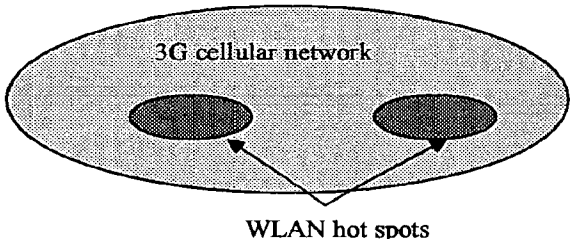

Figure 2. Hot Spot Coverage with Integrated Cellular and WLAN networks

III. Integrated Network Architecture

The Integrated architecture proposes re-using the PDSN of cdma2000 network to forward the WLAN traffic as well. A proxy packet control function introduced at ANG replicates the PCF function of cdma2000 BSC. In this way, it acts as a gateway between the WLAN IP network and the PDSN. The WLAN access network appears as another cdma2000 network to the PDSN (refer Figure 4).

The integrated network architecture re-uses as much as possible from the existing cdma2000 and 802.11 WLAN protocols. Hence, no changes are required to the standard cdma2000 PS service or to the standard 802.11 AP. However, in order to achieve an integrated network operation supporting seamless mobility between the two technologies, the following new functions are introduced.

- The mobile station must have both a WLAN and a cdma2000 radio interface. It makes intelligent decisions on which radio technology to use at any moment, and diverts the PPP frames to the selected radio interface.
- A proxy-PCF (p-PCF) function at ANG (in WLAN IP network) implements the R-P interface in order to communicate to the PDSN.
- An Access Router (AR) discovers and selects a p-PCF in WLAN IP network and tunnels PPP frames from the MS served by its APs to the p-PCF.

Note that the cdma2000 standard allows two modes of IP access; Simple and Mobile IP mode. The Integrated network architecture is transparent to the cdma2000 IP access mode and works well for both methods.

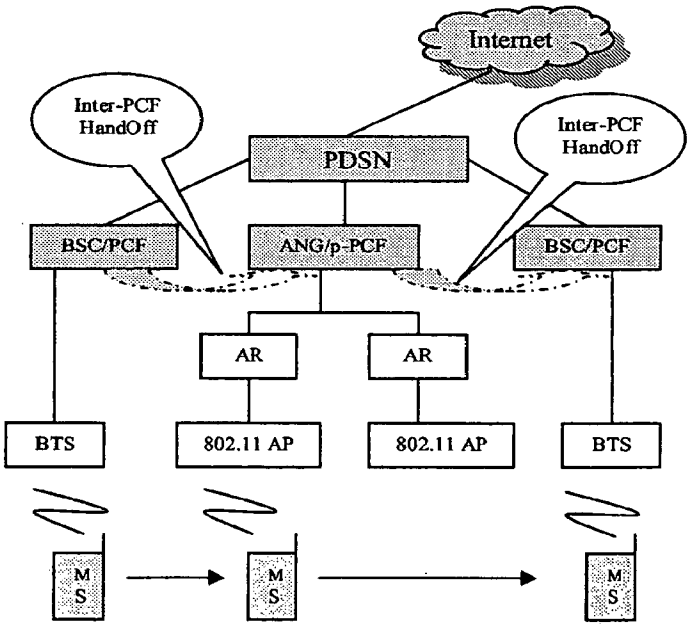

Figure 3. Integrated Network Architecture

In the following sections, we explain the ways in which various access and network operations are supported in the integrated network architecture.

IV. Access Authentication

A. *CDMA2000 Network*

Two levels of security are provided in the cdma2000 network. In the first level of security, the mobile device is authenticated and authorized by mobile switching center (MSC) through the home location register (HLR) and visitor location register (VLR) databases. This is performed prior to

granting access to the radio network for packet data service. In the IP network access security mode, the mobile user is authenticated and authorized using standard authentication, authorization and accounting (AAA) [20] protocol via PDSN. This step is performed prior to granting access to the IP network.

B. *802.11 WLAN Network*

The 802.1x protocol enables access authentication through the 802.11 WLAN access network. This protocol allows the mobile stations (MS) to be authenticated via the access points and vice versa. 802.1x takes advantage of an existing authentication protocol known as the Extensible Authentication Protocol (EAP) [17]. The 802.1x authentication for wireless LANs has three main components: The supplicant (usually the client software in the MS); the authenticator (usually the access point); and the authentication server (usually a Remote Authentication Dial-In User Service server). At the end of the 802.1x transactions, the goal of authenticating the mobile stations by the 802.11 network is completed, enabling the access point port for uninhibited access by the end station. However, this leaves the access point open to attacks by a rogue mobile station that can spoof the identity of the authorized station. The Robust Secure Network Association (RSNA) [19] protocol being standardized by IEEE 802.11i allows for packets between the access point and end station to be encrypted and signed. RSNA uses advanced cryptographic technologies (TKIP, AES) to provide a higher level of security. Once the RSNA exchange has been completed, the end station and the access point have shared secret keys that can be used to encrypt and sign subsequent packets. This allows the access point to indeed ensure that only the authenticated user is using the ports.

V. IP Address Management

The cdma2000 and the WLAN networks may use subnet IP domains that are topologically distinct. At the PDSN, the routing of the IP traffic to/from the MS is performed based on the IP address assigned to the MS by the PDSN during the PPP/IPCP negotiation phase. This address may not be topologically correct when the MS is attached to the WLAN network which may cause the forwarding of IP packets to/from the MS to fail.

The integrated architecture assigns a separate IP transport address to the MS that is used within the WLAN network to route the packets to the AR that is currently serving the MS. This address must be assigned only once when the MS first gets attached to the WLAN network and is not changed as long as the MS is moving within WLAN access network. The AR to which the MS first gets attached in the WLAN network provides or requests this IP address on behalf of the MN -- this address is not visible to the MS itself. The micro-mobility solution used within the WLAN is transparent to the MS and uses this IP transport address to forward packets to/from MS within WLAN network.

VI. Mobility

A. *Mobility across cdma2000 Technology*

Three levels of mobility support are provided in the cdma2000 architecture:

The first level of mobility is at the sector/sector or cell/cell level [5] within the domain of a PCF. This level of mobility is handled at the radio link layer and is hidden from the PDSN and from higher level mobility functions (e.g. Mobile IP foreign agent (FA) and home agent (HA)).

The second level of mobility is across PCF domains within the scope of a PDSN. This is handled by the PDSN because it can be logically connected to more than one PCF. This level of mobility is referred to as "R-P Mobility" or "intra-PDSN Mobility". The R-P interface for a session can be moved from one PCF to the other in such a way that it is transparent to the PPP session running between the MS and the PDSN. Because the PPP session remains on the same PDSN, that session is kept intact and the MS does not need to renegotiate PPP, LCP or IPCP options.

The highest level of mobility in cdma2000 is available only when the PDSN incorporates a Mobile IP Foreign Agent (FA) which allows mobility with respect to the connection point to the Internet to be anchored at the Home Agent (HA). This level of mobility is described as "Macro-Mobility" and allows inter-PDSN mobility to occur. If the mobility handoff results in an connection to a new PCF that does not have access to the old PDSN/FA (inter-PDSN mobility), a new PPP session must be established. When using Mobile IP, the PDSN/FA is informed that a new PPP session is active and the PDSN/FA issues an Agent Advertisement on that session. The mobile responds with a Registration Request which the PDSN/FA forwards to the HA.

B. *Mobility Support across WLAN Technology*

The Inter Access Point Protocol (IAPP) [10] controls the mobility across APs connected through the same AR (an intra-AR handover).

An inter-AR handover, using IP-based micro-mobility mechanisms, is required when the APs involved in the handover are connected to different ARs. The mobile does not change its IP address during the course of its association and de-association with different APs. There are currently no standards in this area, however there are a number of proposed protocols that attempt to solve the local mobility of mobile [12, 13, 14, 15, 16]; the mechanism described earlier under "IP Address Management" is another one of these approaches.

C. *Inter-Technology Handover with 'PCF-Peering'*

The point-to-point protocol (PPP) is the standard mechanism for packet data transport in a cdma2000 network. In order to perform a seamless handoff of the cdma2000 data session, the PPP state must be kept up and running at the two PPP endpoints (MS and the PDSN) before, during and after the handoff. If the PPP session is broken, it takes a minimum of 9 and a maximum of 15 messages between the MS and the PDSN to (re-) negotiate a PPP session. This includes the link

layer, authentication, and network layer negotiation phases, all of which must be re-done if the PPP session is broken; it does not include possible additional messages due to dropped or damaged packets over the air.

As mentioned in previous sections, R-P mobility (Intra-PDSN, Inter-PCF handover) mechanism of the CDMA2000 standard supports the mobility between the PCFs without breaking the PPP session between the MS and the PDSN. The handoff between the two PCFs is performed as a layer 2 handoff while the upper layer states (like the PPP state) remain unchanged. We propose a "PCF-Peering" mechanism that re-uses the concept of inter-PCF, intra-PDSN (R-P mobility) to perform the seamless mobility between cdma2000/ WLAN technologies. The "proxy-PCF" functionality is introduced in the WLAN access network gateway (ANG) which connects the WLAN access network with the cdma2000 PDSN. The WLAN access network is hidden behind this Proxy PCF and appears as a cdma2000 radio access network to the PDSN. The PPP data is transported through the GRE-based interface between the proxy PCF and the PDSN while the data transport between the proxy PCF and the AP still uses the inherited micro mobility and link layer mechanisms of the wireless technology to set up the data transport. Figure 4 presents the network architecture for the integrated cdma2000-WLAN access network with PCF-Peering concept.

1) General Scenarios

Following are the four main scenarios that can be discussed to explain the integrated architecture:

a) MS powers up in cdma2000 network and establishes PPP session with PDSN

b) MS handovers from the WLAN access to cdma2000 access with pre-established PPP state

c) MS powers up in WLAN access networks and establishes PPP state with PDSN

d) MS handovers from the cdma2000 access network with pre-established PPP state

Scenarios (a) and (b) follow the standard cdma2000 procedures described in [6] and are not described further in this document. The following sections capture scenario (c), the power up in 802.11 WLAN access network, and scenario (d), handover from cdma2000 access network to 802.11 access network. Figures 5 and 6 describe the high level interactions between various network elements for power up and handover, scenarios (c) and (d) respectively. In both cases, the communication between the ANG (where p-PCF function resides) and the PDSN follows the cdma2000 standard A11 signalling procedures [6].

2) MS Powers up in WLAN

In scenario (c), during power up in WLAN access network, MS uses the IP address assigned to the MS by the PDSN during the PPP establishment phase to communicate with the AR. However, the routing of IP traffic between the AR and ANG is performed using the WLAN transport address assigned to the MS by the AR during the association phase.

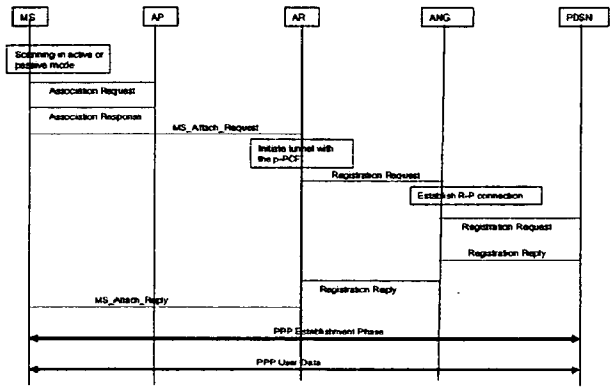

Figure 4. MS Power up in WLAN Procedures

3) Cdma2000 to WLAN Handoff

In scenario (d), when the WLAN air interface of the MS detects strong WLAN coverage while having pre-established data sessions (and hence the PPP state at the PDSN) via cdma2000 access network, it re-uses the PDSN assigned IP address when it attaches to the WLAN network. An inter-PCF handover is performed (between the PCF at cdma2000 BSC and the p-PCF at the WLAN ANG) and the MS continues sending/receiving IP traffic via the WLAN access network. No PPP (re-)establishment is required in this scenario. Once again, the routing of IP traffic between the AR and ANG is performed using the WLAN transport address assigned to the MS by the AR during the association phase.

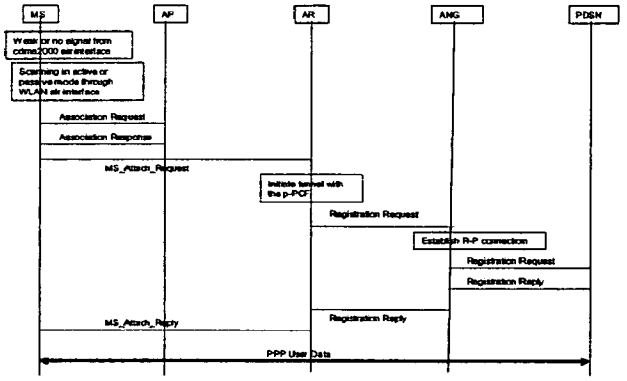

Figure 5. CDMA2000-to-WLAN Handoff Procedures

VII. Packet Transport

The packet transport in the integrated network uses PPP framing between the MS and the PDSN as defined by the cdma2000 standard.

However, the following modes of packet transport are used across WLAN network.

- Layer 2 end points of the data transport are the MS and the AR. The data transport mechanism uses raw encapsulation of PPP packets inside 802.11/Ethernet frames[1]. The MS transmits/receives the PPP data encapsulated in 802.11 frames to/from the AP. The AR transmits/receives the PPP data encapsulated in Ethernet frames.
- Tunneled (PPP-in-IP) transport of the PPP data is used between AR and the ANG/Proxy-PCF.
- Tunneled (PPP-in-GRE) transport of the PPP data is used over the R-P interface.

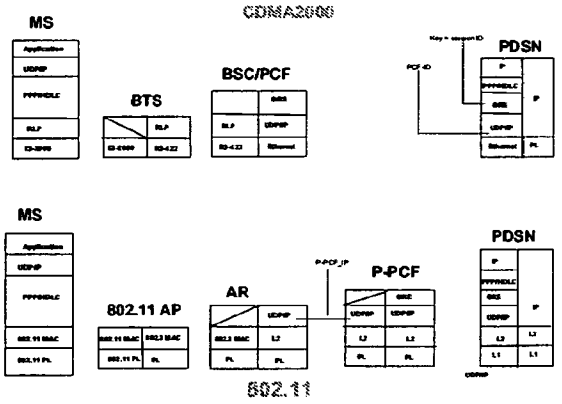

Figure 6. Bearer plane protocol stacks

VIII. ACCOUNTING

Since the PCF-peering mechanism re-uses the R-P mobility concept, the proposed architecture does not require any special mechanism to enable the accounting/charging during handoffs between the cdma2000 and WLAN access networks. The current standard supports mechanisms to inform the AAA server when an R-P interface is moved.

IX. CONCLUSION

In this paper, we presented the unique concept of "PCF-peering" that can be applied to perform seamless handoffs between the 3G cdma2000 and WLAN access technologies. The paper explains the proposed network architecture and the functions that are required at various network elements. The main advantage of the PCF-peering concept is that it uses the existing cdma2000 mobility management mechanisms to handle the handoffs between cellular and WLAN access technologies. The handoff is performed at layer 2 so that the upper layers are not even aware of the change of radio interface. This concept does not require any changes to the existing cdma2000 radio/network standards nor to the WLAN radio standard, allowing it to be introduced into existing cdma2000 and 802.11 networks.

[1] PPP encapsulation over Ethernet is different from PPPoE and is not a standard mechanism as yet

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